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Vol. 18, No. 1, January-February 1984

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USSR REPORT  
SPACE BIOLOGY AND AEROSPACE MEDICINE

Vol. 18, No. 1, January-February 1984

Translation of the Russian-language bimonthly journal KOSMICHESKAYA BIOLOGIYA I AVIAKOSMICHESKAYA MEDITSINA published in Moscow by Izdatel'stvo "Meditrina".

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Man in Space  
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#### ARTICLES BY AMERICAN AUTHORS INCLUDED IN THIS ISSUE

Moscow KOSMICHESKAYA BIOLOGIYA I AVIAKOSMICHESKAYA MEDITSINA in Russian Vol 18, No 1, Jan-Feb 84 (signed to press 28 Dec 83) p 3

[Editorial by editorial board of KOSMICHESKAYA BIOLOGIYA I AVIAKOSMICHESKAYA MEDITSINA]

[Text] Progress in any branch of science is inseparable from extensive exchange of scientific information and learning about the latest advances in science and technology. Bearing this in mind, our journal regularly publishes works not only of Soviet, but foreign specialists, as well as articles prepared together by Soviet and foreign authors.

In this issue, by agreement with the editorial office of the journal, AVIATION, SPACE AND ENVIRONMENTAL MEDICINE, we are publishing articles prepared by the leading specialists of the National Aeronautics and Space Administration (NASA, United States), in addition to Soviet works.

Soviet and American specialists have had many years of experience in effective collaboration in the field of space biology and medicine. We refer to both the exchange of information within the framework of a Soviet-American work group for space biology and medicine (1971-1981) and the successful solution of problems of medical support of the joint mission of Soyuz and Apollo spacecraft (1975), as well as the multivolume joint work, "The Bases of Space Biology and Medicine," published in the USSR and United States in 1975, and joint experiments during missions aboard the Cosmos series of biosatellites (1975-1983).

Proceeding from the decisions of the 26th CPSU Congress, the Soviet Union has always taken the position that space must be an arena for peaceful collaboration between different countries. International missions on the Intercosmos program, as well as the successful flight, in December 1983, of Cosmos-1514 biosatellite, aboard which experiments were conducted with the participation of specialists from the People's Republic of Bulgaria, Hungarian People's Republic, GDR, Polish People's Republic, Socialist Republic of Romania, CSSR, United States and France, are a vivid confirmation of this peace-loving line. Such practical collaboration in peaceful space exploration is an important contribution to the cause of international detente and prevention of the process of militarization of space. It should be noted that Soviet specialists are alarmed by the plans for militarization of space, which have been published in the foreign press, including the United States.

The papers by Soviet and American authors published in this issue have been also published in English, at virtually the same time, in the form of a supplement to the journal, AVIATION, SPACE AND ENVIRONMENTAL MEDICINE,\* and it is the opinion of the editorial offices of both journals that this should be helpful in furnishing quicker and broader information to the scientific community about the latest results of research in such a progressive branch of knowledge as space biology and medicine.

We express our thanks to G. Ya. Tverskaya, Zh. N. Yaroslavtseva and L. V. Leonidova for translating the articles of American authors and to S. O. Nikolayev for their scientific editing.

We also thank Dr S. D. Leverett, chief editor of AVIATION, SPACE AND ENVIRONMENTAL MEDICINE, for publishing the works of Soviet specialists in English.

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\*Translator's note: Vol 54, No 12, Section II, Supplement 1, December 1983.

## BRIEF REPORTS

UDC: 612.741.014.477-064

### MUSCLE TONE CHANGES IN INDIVIDUALS OF DIFFERENT AGE GROUPS SUBMITTED TO SIMULATED WEIGHTLESSNESS

Moscow KOSMICHESKAYA BIOLOGIYA I AVIAKOSMICHESKAYA MEDITSINA in Russian Vol 18, No 1 (manuscript received 25 Nov 82) pp 90-92

[Article by V. G. Kozlova and Ye. A. Il'ina]

[Text] It is known that weightlessness elicits a number of functional changes in the musculoskeletal system [1-5]. The results of numerous studies indicate that the severity of changes that occur depends, to some extent, on flight duration, as well as volume and conditions of physical exercise [6, 7]. The change in muscle tone [8], which is one of the first reactions to altered gravity [9, 10], may be a possible cause of change in coordination of movements as a function of the musculoskeletal system and general work capacity. This view is also confirmed by the results of medical examination of cosmonauts. Thus, already after relatively short spaceflights, diminished tonus of postural muscles was found [11-13]. Investigations of tonus of antigravity muscles in subjects in different age groups, under conditions simulating weightlessness and in particular in an immersion medium, are of great interest.

#### Methods

We used water-immersion hypokinesia with "dry" submersion as a model of weightlessness [14]. Studies were conducted on 24 men 30-49 years of age. Immersion lasted 7 days. The temperature in the immersion tank was held at a constant level ( $33.5 \pm 0.5^\circ\text{C}$ ). Muscle tone was tested on the basis of evaluation of one of its indirect features, the "firmness" of muscle tissue. The tests were performed before and during water-immersion hypokinesia, on the 1st, 3d and 7th days. Tonometry of crural muscles (gastrocnemius--lateral and medial head--GML, GMM; anterior tibial muscle--ATM) and thigh (femoral quadriceps--lateral head--FQ) was performed under standard conditions at rest, with a tonomyometer developed by the Scientific and Technical Department of the Central Scientific Research Institute of Traumatology and Orthopedics [15]. The operation of this instrument is based on consideration of the correlation between resilient deformation, which occurs upon measured depression of the skin at the point of projection of the tested muscle and tension of this muscle. The indicators of exertion applied to the palp of the tonomyometer were recorded in arbitrary units. All of the data were submitted to processing by Student's variation statistical method.

Change in muscle tone (in arbitrary units) during 7-day water-immersion hypokinesia (M $\pm$ m)

Conditions	First group (n = 6)			Second group (n = 8)			Third group (n = 10)		
	ATM	GML	GMM	FQ	ATM	GML	GMM	FQ	ATM
Background	810 $\pm$ 20	700 $\pm$ 23	748 $\pm$ 5	727 $\pm$ 13	840 $\pm$ 18	750 $\pm$ 18	730 $\pm$ 16	780 $\pm$ 12	810 $\pm$ 15
Immersion:	790 $\pm$ 12	700 $\pm$ 15	718 $\pm$ 15	723 $\pm$ 11	810 $\pm$ 10	740 $\pm$ 15	735 $\pm$ 12	760 $\pm$ 10	803 $\pm$ 10
1st day	815 $\pm$ 15	740 $\pm$ 20	708 $\pm$ 17*	670 $\pm$ 7*	816 $\pm$ 9	715 $\pm$ 11*	660 $\pm$ 10*	700 $\pm$ 8*	825 $\pm$ 8
"	820 $\pm$ 15	700 $\pm$ 12	710 $\pm$ 9*	717 $\pm$ 16	830 $\pm$ 8	720 $\pm$ 13	680 $\pm$ 15*	700 $\pm$ 9*	828 $\pm$ 11
7th									

\*Reliability of differences is P<0.05, as compared to background.

The older subjects, who had no experience with water-immersion hypokinesia, constituted the first group; those 30-35 years of age, who also did not have experience in working under conditions of simulated weightlessness, made up the second group, while those 30-35 years of age, who had been repeatedly submitted to immersion constituted the third group.

#### Results and Discussion

As can be seen in the Table, there were similar changes in muscle tone in the 1st and 2d groups of subjects during immersion. A decrease in muscle tone, which did not exceed 10%, was seen only starting on the 3d day of immersion and persisted up to the 7th day. Along with decrease in tonus of some muscle groups, in particular the gastrocnemius, there was a tendency toward its increase in other muscle groups (rectus of FQ, abdominal muscles). This was the most marked in the 1st group of subjects.

Analysis of the results of testing the 3d group revealed that, already after 1 day of immersion, there was a 13% decrease in tonus of the gastrocnemius and 12% decrease for the femoral muscles. ATM tonus did not change. By the 4th day of immersion there was a tendency toward normalization of muscle tone and on the 7th day again a decrease. Analogous changes in muscle tone after subjects were submitted to a water environment had been noted by N. Ye. Panferova [16].

The decrease of muscle tone in the 1st and 2d groups noted only starting on the 3d day (unlike the 3d group of subjects) is apparently indicative of existence of special stationary excitation in the nerve centers of individuals submitted for the first time to water-immersion hypokinesia. It is known that a change in functional state of nerve centers leads to a change in descending influences on muscles [17-19].

These findings characterize the process of man's adaptation to new functional conditions. Repeated immersion lowers the emotional factor; physiological reactions related to redistribution of blood and the absence of static load move to the fore. Muscle tone, as determined

by evaluation of "firmness" of muscle tissue, is an integral indicator of the functional state of a muscle, and it characterizes an entire set of muscle properties. The decrease in tonus, which was observed on the 1st day of immersion, was apparently attributable to a greater extent to relative dehydration of the body [20], whereas on the 7th day the absence of a static load becomes the most significant factor.

A comparison of changes demonstrated in the three groups indicates that there are changes in the same direction in muscle tone under conditions simulating weightlessness in subjects of different age groups. The factor of repeated immersion is of decisive significance.

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## CURRENT EVENTS AND INFORMATION

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### THIRTEENTH GAGARIN CONFERENCE

Moscow KOSMICHESKAYA BIOLOGIYA I AVIAKOSMICHESKAYA MEDITSINA in Russian Vol 18, No 1, Jan-Feb 84 (signed to press 28 Dec 83) pp 92-95

[Article by A. A. Gyurdzhian, S. M. Ledovskoy and V. I. Savchenko]

[Text] The 13th Annual (Gagarin) Conference on Aviation and Cosmonautics was held in Moscow from 4 to 8 April 1983.

There were two plenary sessions. A. G. NIKOLAYEV, USSR pilot-cosmonaut, delivered the opening remarks before the first plenary session on 6 April in Zvezdnyy, after solemnly laying flowers by the Yu. A. Gagarin memorial. P. R. POPOVICH, USSR pilot-cosmonaut, spoke about the experience of training and results of participating in the world's longest, 211-day manned flight. V. A. DZHANIBEKOV, USSR pilot-cosmonaut, delivered a very interesting report about the mission and scientific research performed by the joint Soviet-French crew.

In the last paper, entitled "Space Monitoring of Anthropogenic Factors and Related Effects," delivered by YU. A. IZRAEL' (coauthor--YU. V. NOVIKOV, corresponding member of the USSR Academy of Sciences, described the problems of interaction between man in spaceflight and his environment (biosphere).

The second and final plenary session convened on 8 April at the Institute of Problems of Mechanics, USSR Academy of Sciences. The following papers were delivered: "Some Problems of Space Technology," by L. V. LESKOV (together with Academician V. S. AVDUEVSKIY) and "Preliminary Medical Findings in 211-Day Mission of Salyut-7--Soyuz Orbital Complex" by N. N. GUROVSKIY (together with Academician O. G. GAZENKO and A. D. YEGOROV).

The last paper discussed the results of the longest spaceflight and man's ability to work in space for a long period of time. Hemodynamics, fluid-electrolyte and energy metabolism of both cosmonauts, circulating blood volume, its amino acid composition and acetylcholinesterase activity, immunological indicators, dynamics of weight loss of body and its different parts and organs were submitted to analysis for the different stages of flight. In addition, the results were reported of studies of motor functions (muscle tone, ability to perform physical work), cardiovascular reactions to physical load, as well as wellbeing of cosmonauts (flushing of the head at the early stages of flight), their neuropsychological condition and time required for total

recovery and elimination of postflight feeling of fatigue. This period lasts up to 45 days.

Then V. N. SAGINOV, deputy chairman of the Gagarin Committee, summed up the work of the different sections. He stated that more than 400 papers were delivered and discussed in the 10 sections. It is very important that, within the limits of the Gagarin conferences, there are annual Gagarin conferences for students, the participants of which are representatives of VUZ's all over the Soviet Union. These lectures are a remarkable school of scientific and technological creativity for the students. In 1983, there was a particularly representative composition of participants at the student conference. More than 450 papers were delivered at the 10 sections. V. N. Saginov submitted the proposal that there be a permanent year-round seminar related to all sections, at which it would be possible to discuss and select papers for the next Gagarin conferences.

At the end of the meeting, N. N. RUKAVISHNIKOV, USSR pilot-cosmonaut and chairman of the USSR Federation of Cosmonautics, gave Federation awards to the most active participants of the Gagarin Conference.

Section of aviation and space medicine and biology. Sessions of the biomedical section of the 13th Gagarin Conference convened in April (4, 5 and 7) 1983; they constitute a sort of annual report by specialists about the work they have done.

More than 180 participants and guests from Moscow, Leningrad and other cities of our country discussed for 3 days pressing problems of aerospace medicine and biology.

A total of 37 papers (93 authors from 24 scientific research institutions) were delivered and discussed.

The opening remarks at this section meeting, which dealt with the status and prospects of development of aerospace medicine and biology, were delivered by Academician O. G. GAZENKO. Papers dealing with the following subjects were delivered at the three meetings of the section (which could be called sub-sections): psychophysiology of operator performance; effect of flight factors on the body; symptomatology, expertise, nutrition; gravity biology.

First meeting: The problem of studying the psychophysiological characteristics of an operator in the man-machine-environment system is one of the most urgent problems of our times. This is attributable to the rapid development of new technology, especially in aviation and cosmonautics.

Knowledge of relations between the functional state of an operator and characteristics of the work process is an important condition for optimizing any man-machine-environment system, as well as for improving its efficiency and quality. This correlation is quite complex. One of the most important directions of aerospace medicine is to disclose its substance.

Several papers dealt with the performance of flight personnel. N. A. OSADCHIYEVA and V. D. GLUKHOVSKIY used psychophysiological techniques to study the effects of actual commercial flights on the crew of civil aviation helicopters. As a

result of analysis of these studies, the authors prepared recommendations to improve working and rest conditions for the crews of Mi-6 helicopters.

The paper of P. A. KOVALENKO pertained to a study of pilots' ability for spatial orientation according to banking and pitching, as well as a description and validation of effective methods of spatial orientation. His findings resulted in using effective methods of spatial orientation as the basis of training methods in civil aviation schools.

G. M. ZARAKOVSKIY et al. demonstrated the effect of sensory restrictions and deprivation on artistic perception and emotions of man. According to his findings, it is necessary to take into consideration both any possible changes in artistic taste and personality distinctions related to cognitive skills and esthetic and emotional experience for determination of the composition and form of presentation of works of art for purposes of "psychological support" of operators.

YU. V. KRYLOV et al., who studied the possibility of good articulation of verbal signals in a confined space, established that the optimum size of space under a mask is 50-200 cm<sup>3</sup>. A larger or smaller space affects the acoustic capabilities of individual gear to protect respiratory organs. At the same time, it was shown that the parameters of the condition of the speech-forming tract make it possible to define the optimum size of the space under a mask, with which intelligibility of speech is at a maximum under given conditions.

YE. V. DEMENT'YEV et al. developed an experimental device and conducted studies in order to determine the permissible discrepancy between convergent set of the eyes and accommodation at which observation can be pursued by an operator for a long period of time without onset of asthenopic signs under conditions of simulating objects at an infinite distance. The results could be used to set the specifications for quality of image collimation in simulating the visual situation on trainers. With reference to optimum methods of constructing optical systems for simulating relative distance, the speaker confirmed the feasibility and desirability of using optical systems to simulate relative distance in trainers and simulator complexes.

V. I. MAKAROV, who studied ultraradian rhythms, among which special attention was devoted to cycles with a period of about 90 min, provided the quantitative validations for regulating man's activities in the presence of such rhythms. A. A. KORESHKOV and V. I. MAKAROV, who used the biorhythmological approach to diagnosis of condition and forecasting operator behavior in emotiogenic situations, arrived at the conclusion that a sudden emotional factor coinciding with sleepiness, which occurs periodically under monotonous conditions, has a particularly adverse effect on the quality and productivity of operator work.

The paper of V. I. KOPANEV et al. discussed questions of investigating some psychophysiological functions of operators during monotonous activity in a state of working hypokinesia and relative sensory deprivation. The authors, who used tests of reactions to moving objects and "carrying capacity" of operators, found that a low level of physiological functions and their inertia occur under monotonous conditions, and this has an appreciable effect on quality of task performance and operator reliability in the course of prolonged monotonous work.

Considering that the causes of some accidents and incidents are referable to inadequate reflection of the situation in man's consciousness, V. G. KOSTRITSA made an experimental study of the effect of mild changes in initial mental state on such an important operator quality as reliability. He concluded that a mild change in mental status, both in the direction of activity and inhibition, could lead to a decrease in operator reliability.

M. YU. TELEGIN studied the effect of a lag in confirmation signal about the result of performance of an additional action on quality of combined work. He concluded on the basis of these findings that the time of receipt of a confirmation signal influences operator stress, the quality of his work and speed of detection of this signal, depending on the difficulty of his basic work.

The subject of the studies of M. F. FROLOV et al. was training in voluntary control of one's functional status in a system with biological feedback, on the basis of the laws of adaptive self-regulation. The data obtained in the course of the studies confirmed the preliminary hypothesis that training in a system with biological feedback reduces appreciably mistakes in solving operator problems with concurrent reduction in physiological expenditure for performance of a given type of work and emotional stress under complicated conditions.

The goal of the work of YE. M. VAKULKO and B. I. PARMENOV-TRIFILOV was to validate the standards of fitness of aviation trainers, with consideration of the distinctions involved in studying the psychophysiological parameters of operators. These authors correctly noted that there is a need for special studies that would permit preparation of a norm document that regulates development, testing, acceptance and operation of trainers.

Development and inception of a new branch of psychological science, space psychology, was the subject of the comprehensive paper of N. V. KRYLOVA and A. K. BOKOVIKOV.

Second meeting: Eight papers were delivered on the topic of "Influence of Flight Factors on the Body." They were all concerned with methods of simulating the different physiological effects of weightlessness and prevention of adverse effects. New findings were reported of a study of the consequences of long-term hypokinesia, physiological and hygienic aspects of protecting man against deleterious factors.

L. S. GRIGOR'YEVA and I. B. KOZLOVSKAYA studied the effect of 7-day immersion hypokinesia on precision movements. In the opinion of these authors, the demonstrated changes in structure of precision movements are attributable to absence of static load and related changes in proprioceptive influx. The same authors, together with YE. A. IL'INSKAYA, suggested the use, in addition to the currently used conditions of electrostimulation, of a modification of this treatment that selectively affects trigger mechanisms of motor disturbances in weightlessness.

A team of authors (T. A. KABESHEVA, S. V. KOPANEV and others), who studied the dynamics of vascular tonus with numerous exposures to head-down tilt, established

that conditioning for antiorthostatic position [head-down tilt] (active antiorthostasis) results in development of mechanisms that prevent excessive plethora of the brain, on the one hand, and instrumental in retaining fluid in the limbs and unloading the central vascular system, on the other.

The paper of A. S. USHAKOV, M. S. BELAKOVSKIY and others discussed the results of studies of calcium and phosphorus metabolism and condition of bone tissue of hypokinetic rats flown in Cosmos series biosatellites. Data were submitted concerning the possible role of vitamin D in development of disturbances in this type of metabolism under hypokinetic conditions. They discussed the possibility of using vitamin D metabolites to prevent disturbances in calcium and phosphorus metabolism under hypokinetic conditions.

At the present time, the centrifuge is the main and virtually only means of adequately simulating accelerations in aerospace medicine. However, the great technical complexity of the centrifuge, high cost of equipment and operation are stimulating an active search for new, simpler and accessible means of simulating accelerations. A team of authors (A. V. KONDAKOV, M. A. TIKHONOV and others) proposed as such a model rapid (up to -30 mm Hg per second) decompression of the lower body, simulating a rapid gradient of build-up of hydrostatic blood pressure at accelerations of +Gz.

The paper of YE. M. PESHKOV and V. B. CHERTOK discussed physiological and hygienic problems of protecting passengers during high-altitude flights, submitting examples of solving the problem of physiological protection of passengers during high-altitude flights in certain types of aircraft.

The need to work out a criterion of intensity of sonic booms, which would make it possible to obtain more objective results of studies to set standards on intensity of sonic booms from supersonic transport aircraft, was demonstrated by A. F. LUKINOV. This criterion could be used in designing and operating the pertinent aircraft.

The results of the studies pursued by B. G. LYTKIN and A. K. SGIBNEV indicate that low humidity at comfortable air temperature has an adverse effect on heat exchange and functional state of the body; it elicits a decrease in work capacity of flight personnel and causes diseases of the upper respiratory tract. These findings can be used to validate the scientifically permissible humidity in the crew cabins of civil aviation aircraft.

Third meeting: Questions of symptomatology, expertise, gravity biology and a few others were discussed at this meeting.

D. A. ALEKSEYEV, KH. KH. YARULIN and others studied distinctions of cerebral hemodynamics and neurodynamics in individuals over 40 years of age with early manifestation of vegetovascular dystonia (VVD) during exposure to heat and hypoxic hypoxia. They demonstrated that, in the presence of VVD of the hypertensive type, there is rather high resistance to heat and hypoxic hypoxia. With VVD of the hypotensive type, there was low tolerance of heat and hypoxia tests. Healthy subjects over 40 years of age showed virtually no difference from the tested control group (of a younger age) in resistance to the above adverse factors.

The paper of T. A. KRUPINA et al. also dealt with clinical and experimental validation of screening scientist-cosmonauts. Their studies revealed age-related distinctions and functional capabilities of the cardiovascular system and metabolism of individuals 40-49 and 50-56 years old. They developed a set of the most informative criteria and tests in order to solve questions of expertise in screening this group of cosmonauts.

The capabilities of nystagmometry for detection of latent vestibular dysfunction and desirability of using it in professional screening were discussed in the very interesting paper of T. A. NALIMOVA et al.

In the opinion of L. S. SHAPOVALOV et al., the laser refractometric method of determining the optical set of the eyes of civil aviation flight personnel could play an important part in assessing results of observations using optical instruments and in ophthalmo-ergonomics. In cases of ametropia, laser refractometry helps avoid hypercorrection of glasses.

V. I. PARMENOV-TRIFILOV and V. I. ONISHCHIK conducted clinical roentgenological and electrophysiological studies using functional load tests on 160 pilots with degenerative-dystrophic diseases of the spine. In 99.8% of the cases, vertebrobasilar insufficiency of cerebral circulation appeared with the combination of vasotrophic and viscerovascular disturbances. A correlation was demonstrated between vascular compensation and general hemodynamic condition, which is quite relevant to expert medical certification of flight personnel.

I. G. POPOV and A. A. LATSKEVICH, who studied nutrition and amino acid metabolism of cosmonauts during long-term flights, suggested that the amounts of several amino acids in the food allowance be increased to prevent changes in amino acid metabolism that depend on the nutritional factor.

In view of the longer duration of spaceflights, researchers are being faced increasingly often with the following problems of gravity biology: distinctions of vital functions and behavior of terrestrial organisms while in flight vehicles under conditions of altered gravity, ecophysiology (extraterrestrial life of terrestrial organisms); principles and methods of designing an artificial habitat in spacecraft and stations (biotechnology, ecology of closed systems).

According to the data of E. A. OYGENBLIK, who studied embryonic development of amphibians during centrifugation, the fourth stage of embryo development (gastrula-neurula) is highly sensitive to hypergravity. The study of YE. M. CHARDANTSEVA, which dealt with embryonic development of fish under altered gravity, indicates that, in the case of meroblast type of development, a change in gravity has virtually no effect on the course of morphogenesis.

Two papers dealt with the study of plant life in weightlessness. The one delivered by G. P. PARFENOV shed light on the substance of the problem as a whole and demonstrated that there are insufficient grounds to expect basic changes in the form or dimensions of plants in weightlessness. M. G. TAIRBEKOV assumes that there is a decline in overall energy expended by the plant organism in weightlessness, as compared to conditions on earth.

YE. YA. SHEPELEV et al. devoted their paper to a biological life-support system for man; they designed an extremely simple model of a man-Chlorella-mineralization system, which makes it possible to pursue quantitative studies of biological and abiotic relations under strictly controlled conditions and thus obtain the needed data to turn to development of models of more complicated systems. They also established that development of such a system could provide for regeneration of the atmosphere, water and, in part, food, which constitutes about 80% of human metabolic needs.

A. N. KOZLOV and V. S. BEDNENKO reported about a device they developed, that can transmit via a single channel the indicators of pulse and respiration rate, dynamics of cardiac output and coronary blood flow. This expands the informative capabilities of the medical monitoring system and makes it possible to develop algorithms for automatic processing.

In conclusion, A. A. GYURDZHIAN, who chaired the last meeting, offered his sincere thanks to the participants on behalf of the Gagarin Committee and voiced his deep conviction that strengthening the creative contacts between representatives of biomedical, sociopsychological and engineering disciplines is an assurance of further progress in aerospace medicine.

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